METERON – Validating Orbit-to-Ground Telerobotics Operations Technologies

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European Space Agency

METERON
Overall Goals of the METERON Project

METERON – will be a platform to provide '*educated answers*' to the question of

how future "operator in space" robotic mission architectures need to be implemented !

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Overall Goals of the METERON Project

METERON = Multi-Purpose End-To-End Robotic Operation Network –

An experiment & architecture to validate human-robotic operations from space using the ISS

PRIMARY GOALS

– **ROBOTICS**
  - **Technology Validation**
  - **Telepresence in space (-µG) environment**
  - **Shared-autonomous control**

– **OPERATIONS**
  - **End-To-End Mission simulation**
  - **Multi-homed control centers**
  - **Real-time (~ ms) mission operations**

– **COMMUNICATIONS**
  - **Disruption / Delay Tolerant Networking**
  - **Real-time comm's**

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Overall Goals of the METERON Project

Why do we want to use ISS for such research under METERON ?

On Ground, it is …

- **IMPOSSIBLE**
  to simulate microgravity,

- **DIFFICULT**
  to simulate the environment factors (mental load, comm's, etc.),

- **SENSELESS**
  To simulate the complexity of the infrastructure and operation processes.

ISS currently is the most realistic environment that resembles future manned exploration missions ! *We want to use it, because 'we can'.*

Mission Architecture

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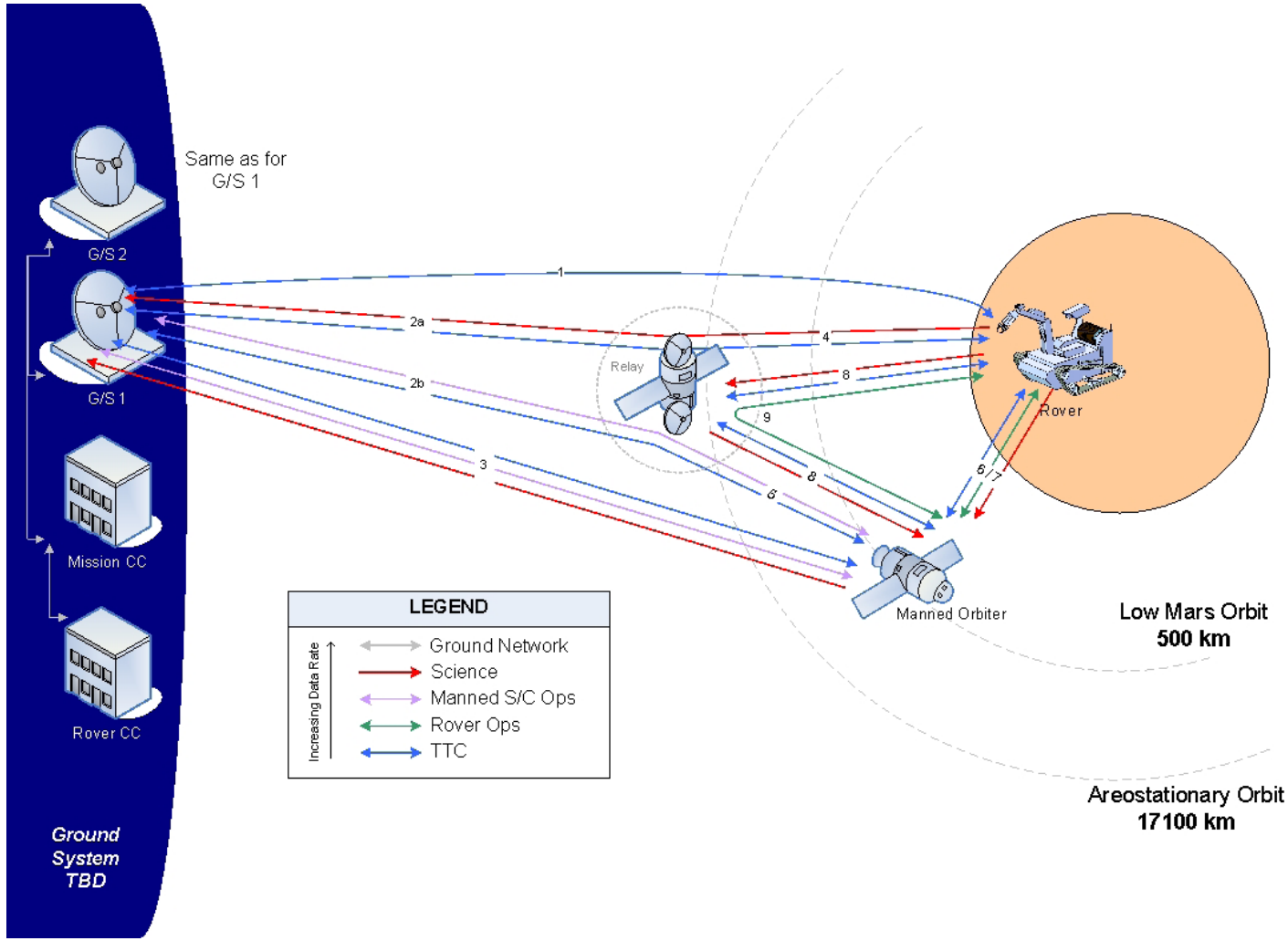
Reference Architecture – e.g. Mars exploration



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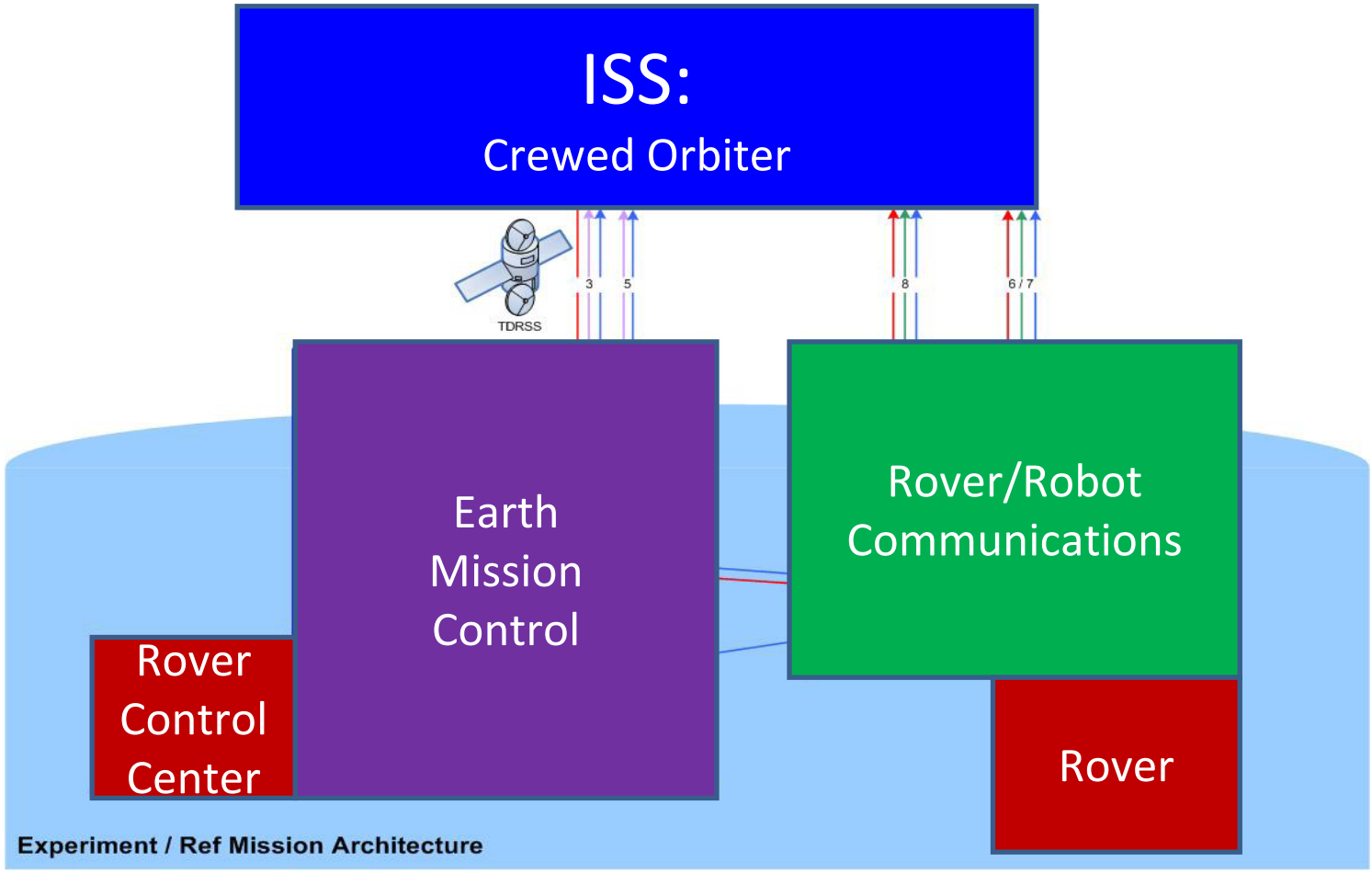
Concept of METERON System



Robotic Experiment

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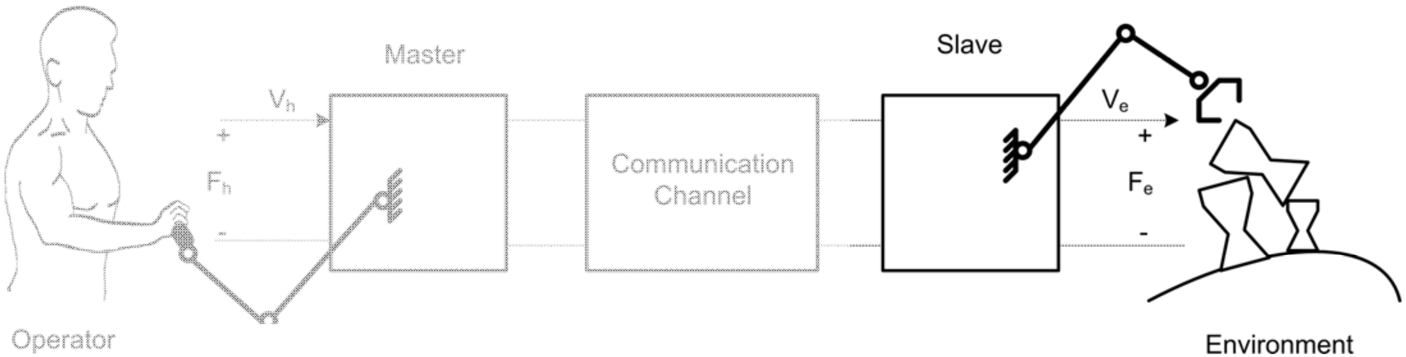
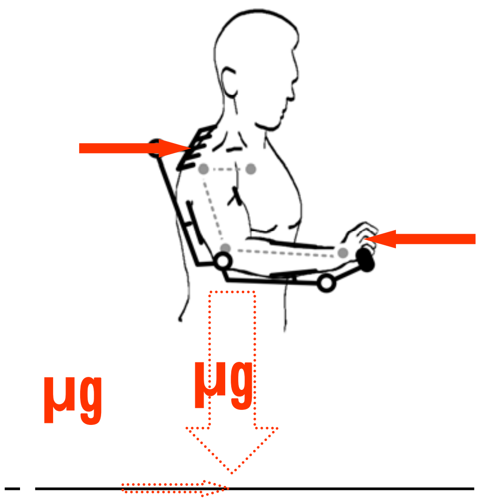
Robotics Experiments – Scientific objective

- **Exact analysis of advanced Human-Robot Interface performance in highly constraint environments (for control of robotic mobility, manipulation and mobile manipulation).**





Exoskeleton devices ideal for Micro-Gravity application
Endpoint devices: E.g. Phantom, Omega, Delta Devices, Force-feedback Joysticks, etc..

Function only under gravity !

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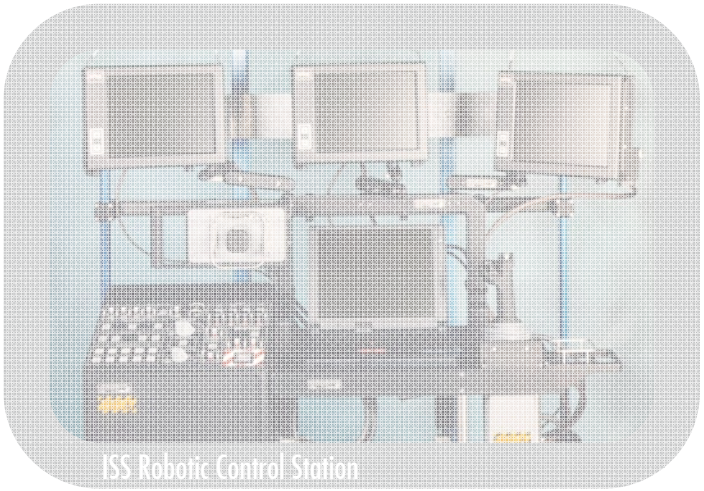
Robotics Experiments – On-board segment up-grade



State Control

State Control

State Feedback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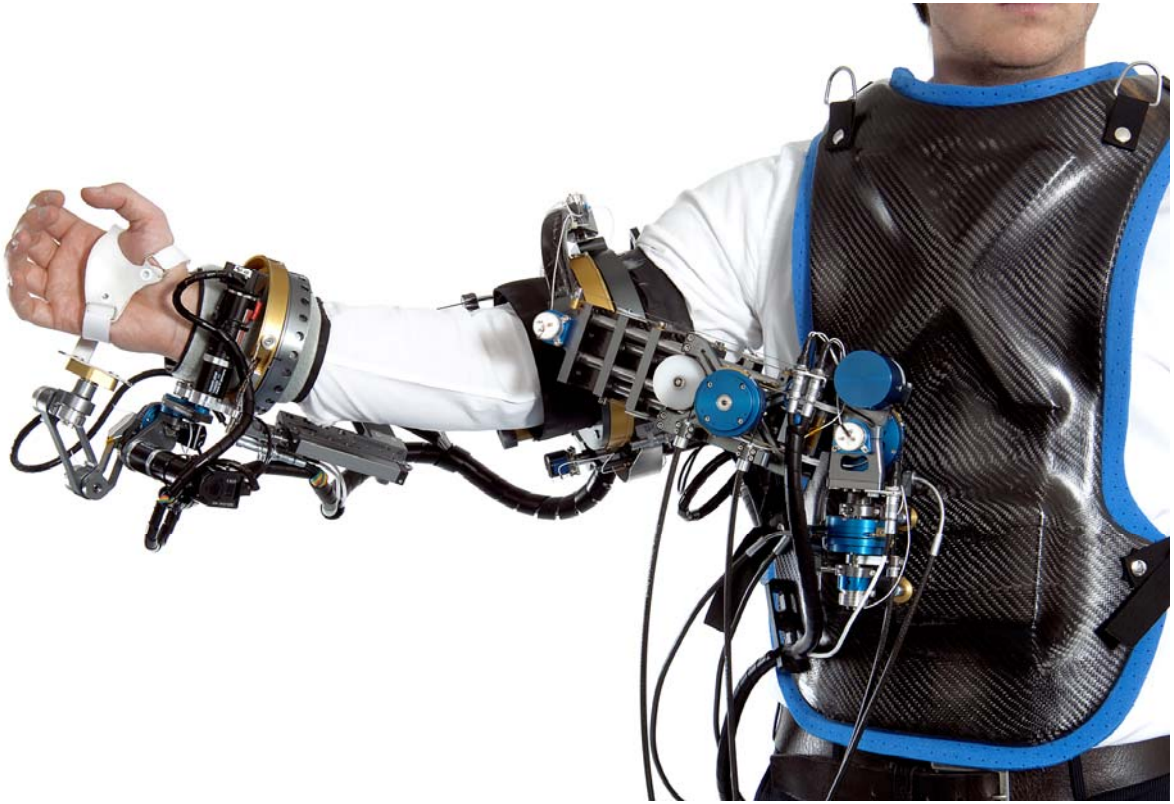
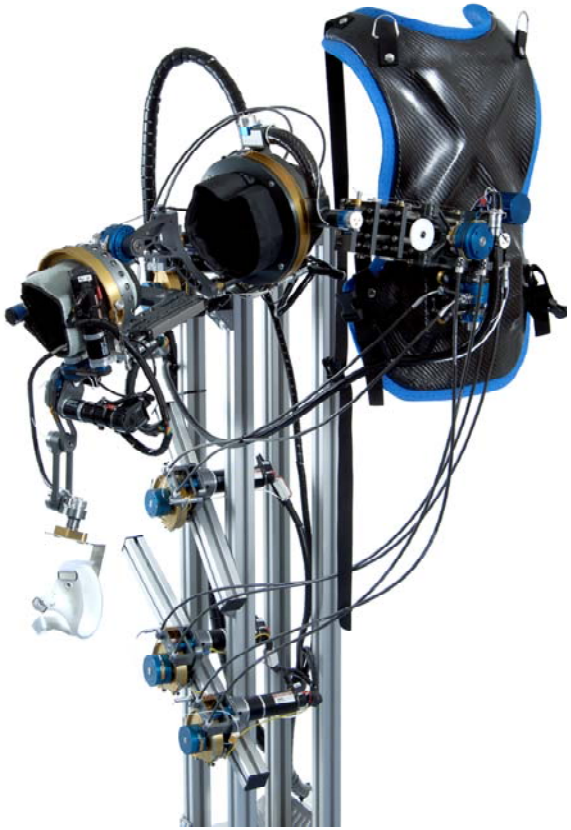
Robotic Technology:: Exoskeleton – X-Arm-2





[A. Schiele and G. Hirzinger, IEEE IROS 2011, submitted]

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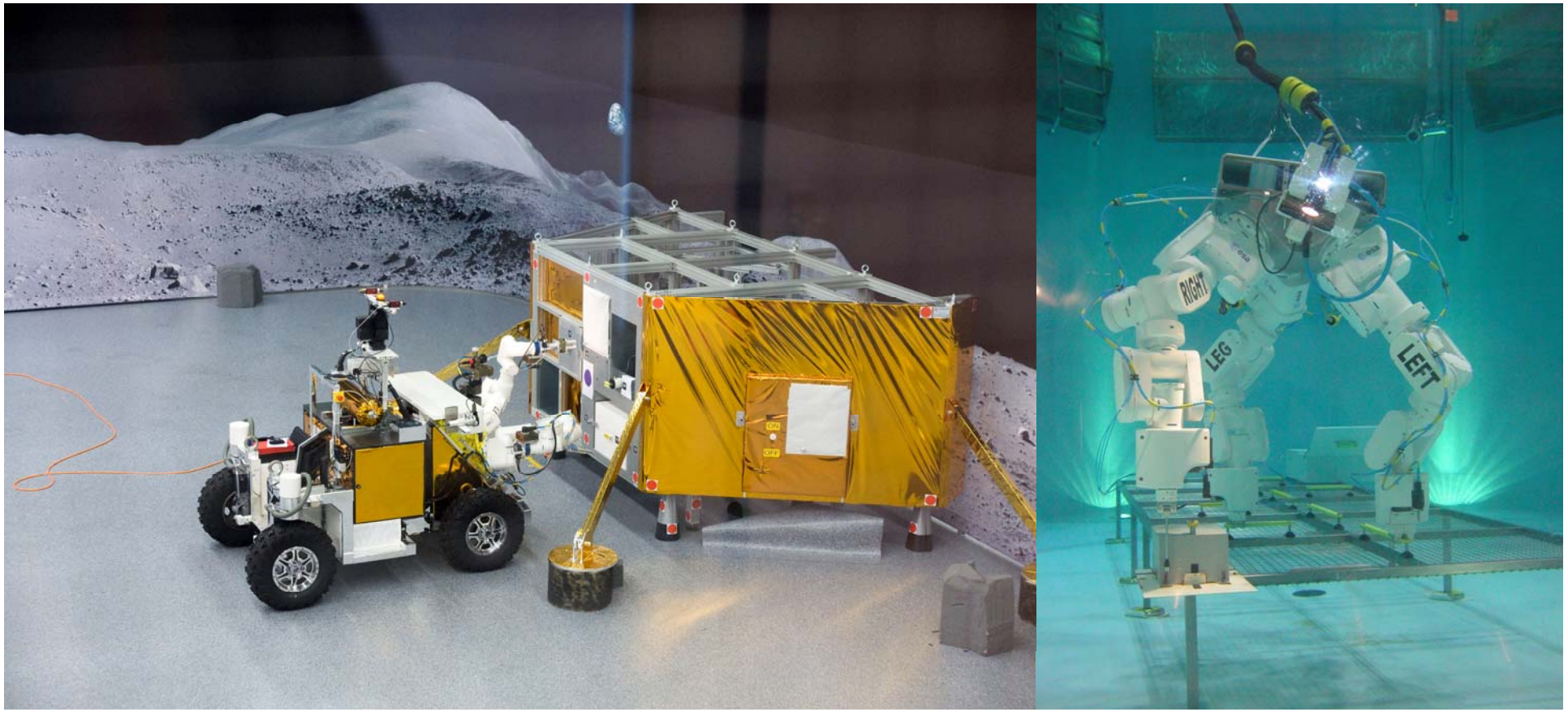
Robotic Technology:: EUROBOT – Ground Prototype



[F. Didot, P. Schoonejans et al., ASTRA 2006]

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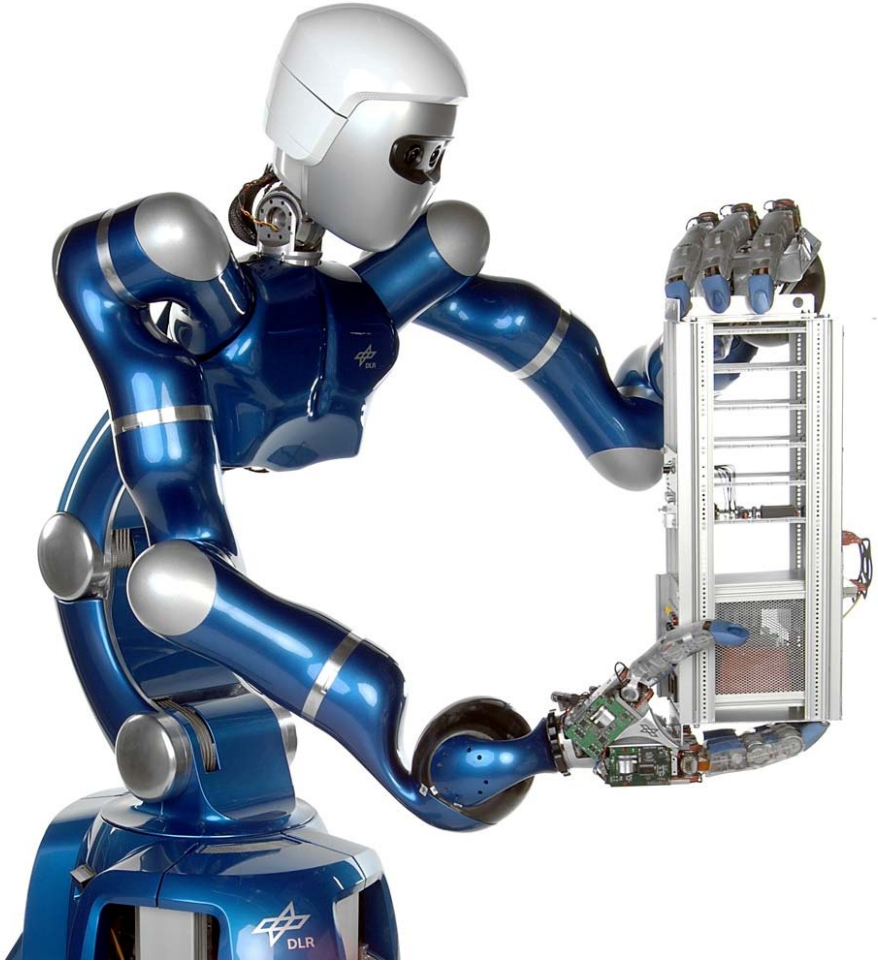
Robotic Technology:: Rollin' JUSTIN



(Courtesy: DLR RM, Oberpfaffenhofen)

[C. Borst et al., IEEE ICRA 2009]

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Robotic Technology:: Robonaut R2

(Courtesy: NASA JSC, General Motors Inc.)

[R. Ambrose et al., IEEE Intell. Systems 2000]


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System Implementation
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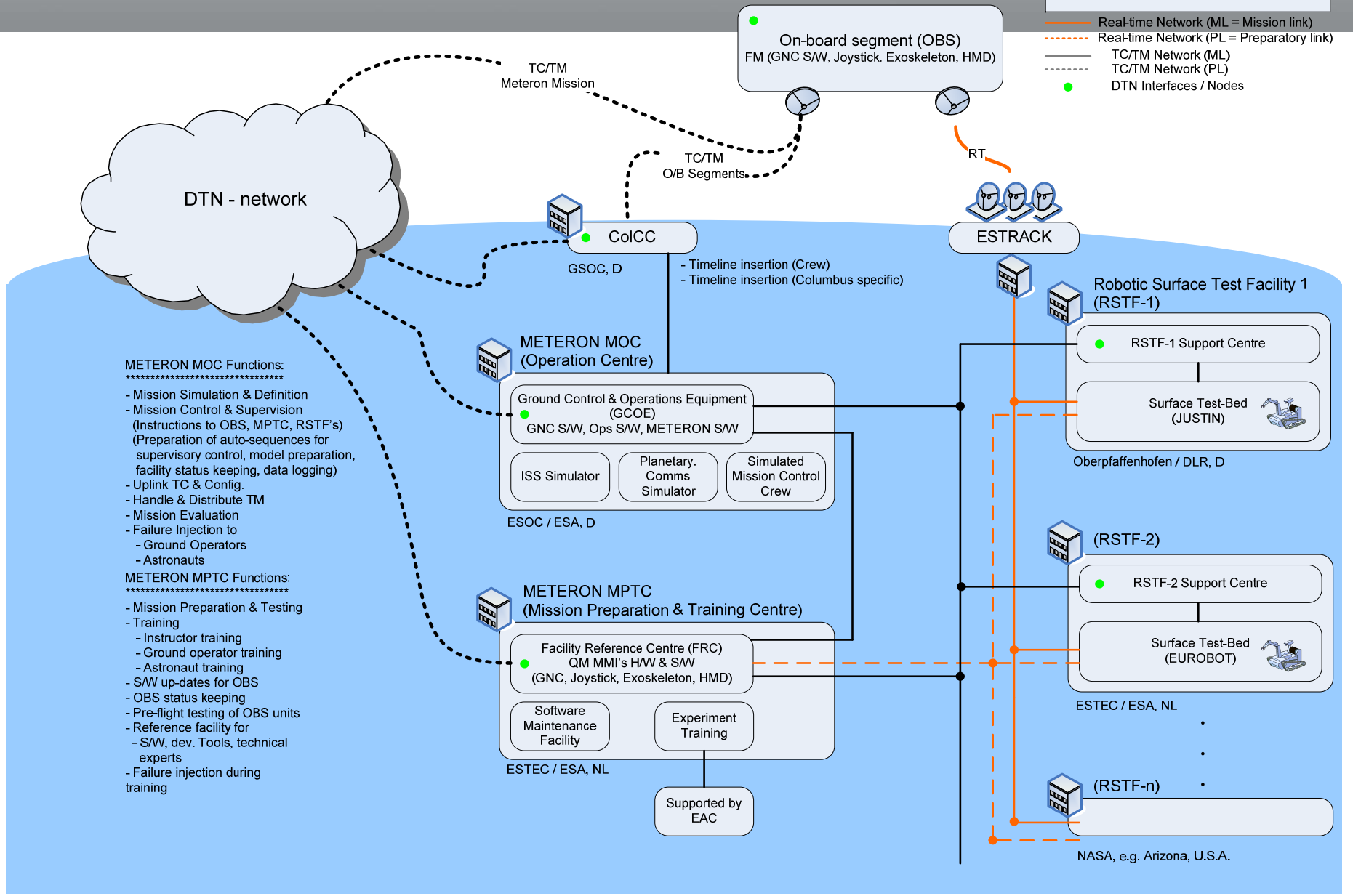
Ground Segment – Full Architecture



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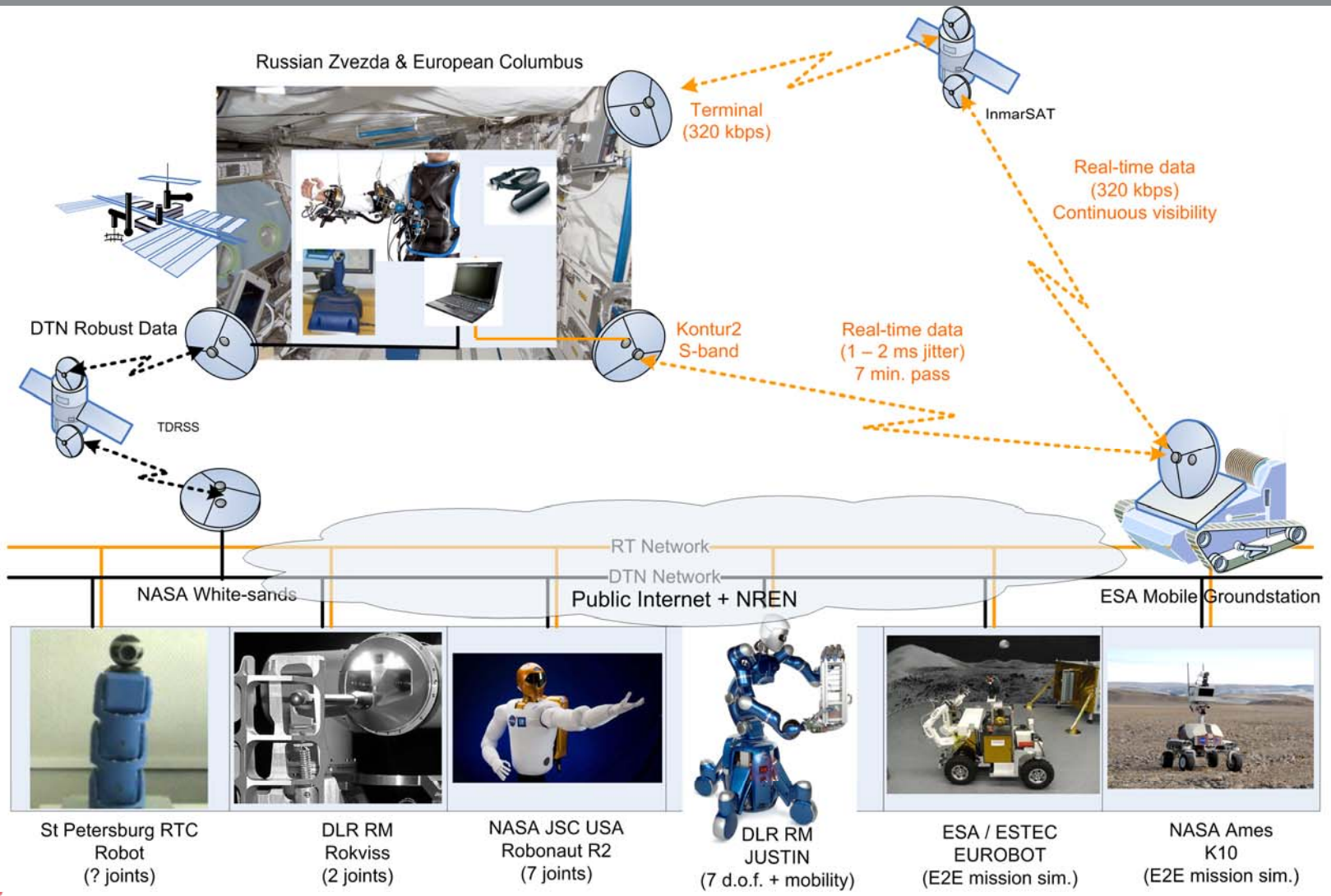
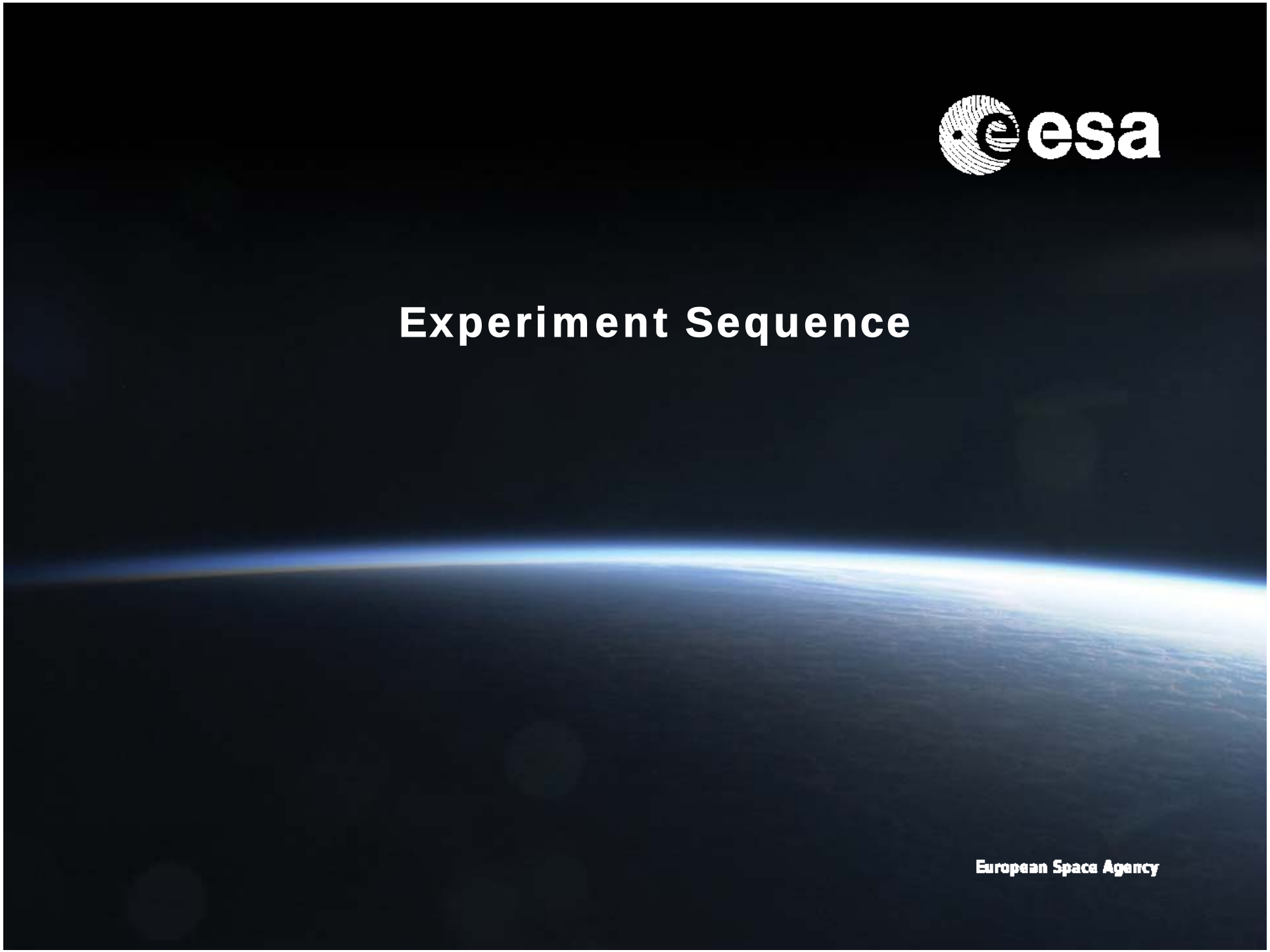
Full METERON System – Robotics Perspective



Experiment Sequence



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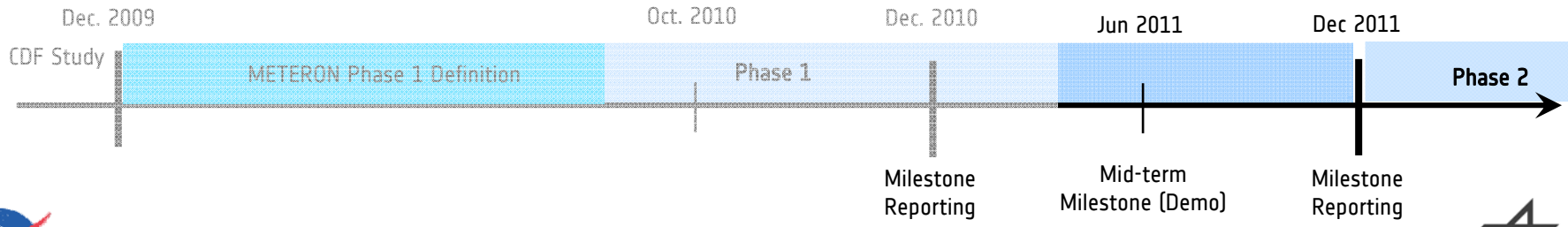
Sequential Approach:: Experiments – Increments

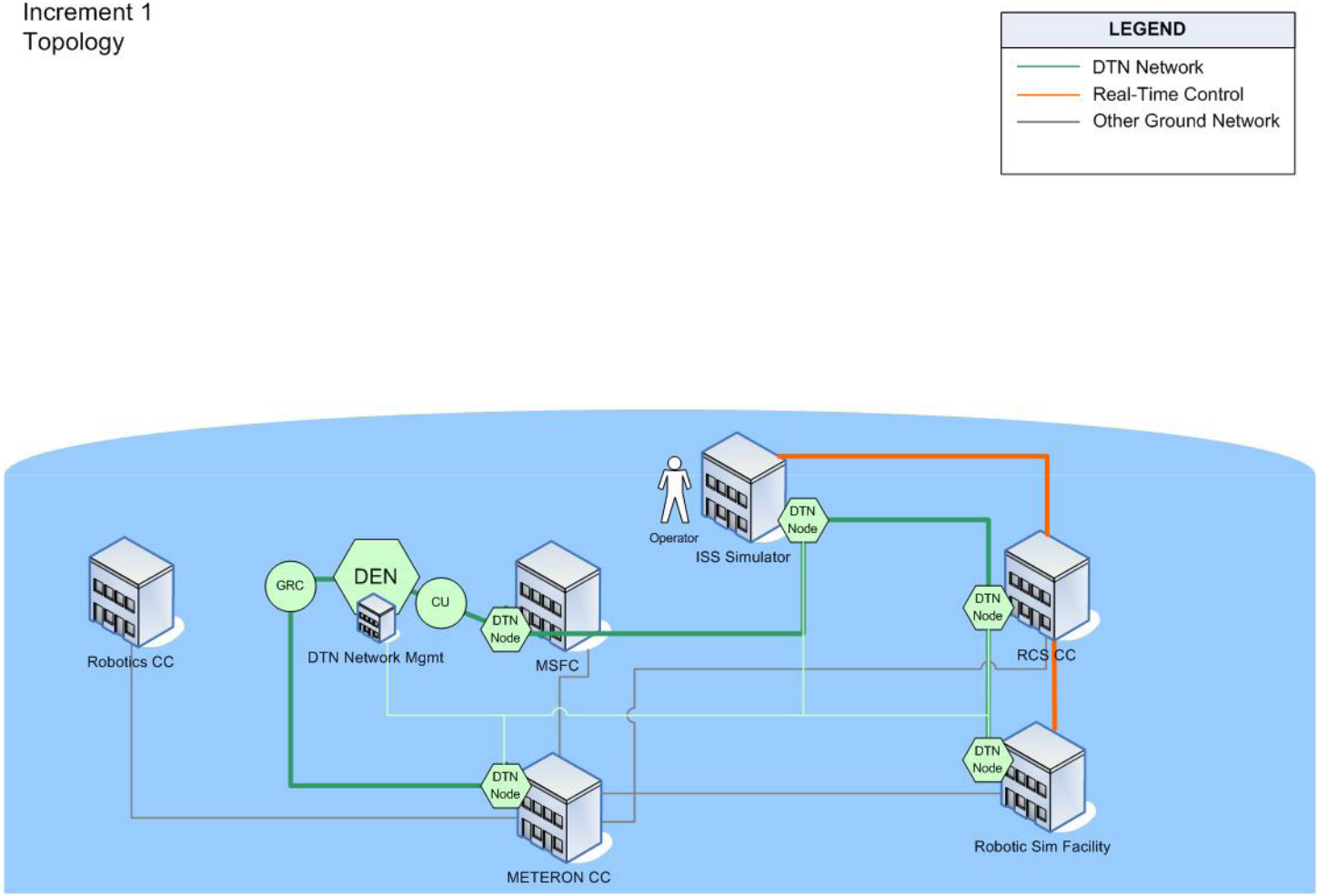
Experiments will be implemented incrementally, in two phases

- PHASE 1: - *Dec. 2010*
  - Demonstrate feasibility of robotics experiments by preparing missing technologies and showing sub-system feasibility of exoskeleton and robot control up to TRL-5 and -6.
  - Increment 0 (ongoing)

- PHASE 2: - *2015*
  - Investigate benefit of haptics and immersive technologies for remote robot operations on astronaut performance from within a highly constrained zero-G environment.
  - Increments 1 – 5



Increment 1
Topology



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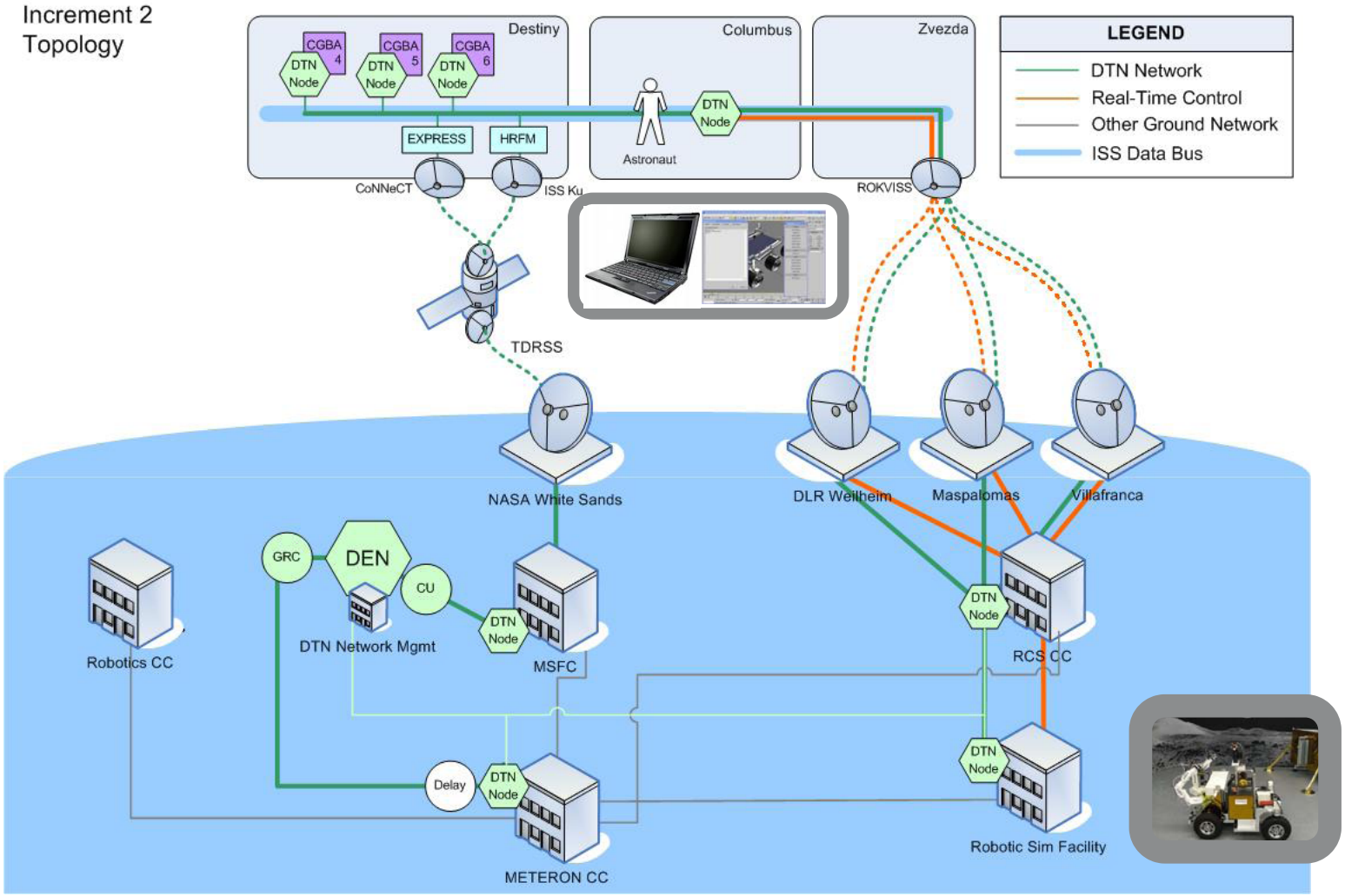
Phase 2 – Increment 2

Increment 2
Topology



Supervisory control experiments

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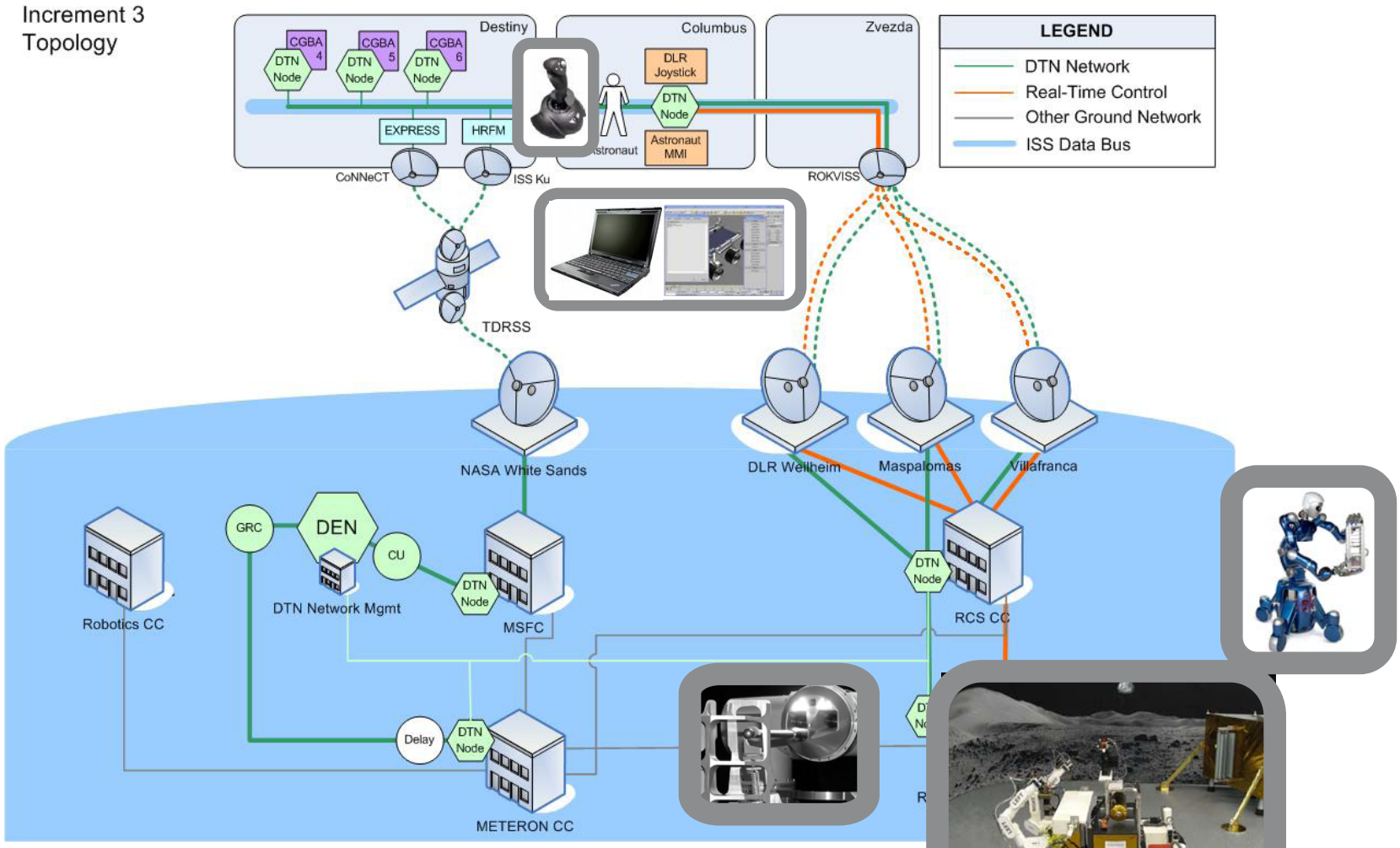
Phase 2 – Increment 3

Increment 3
Topology



Non Body-grounded F.-Feedback + Mobility control

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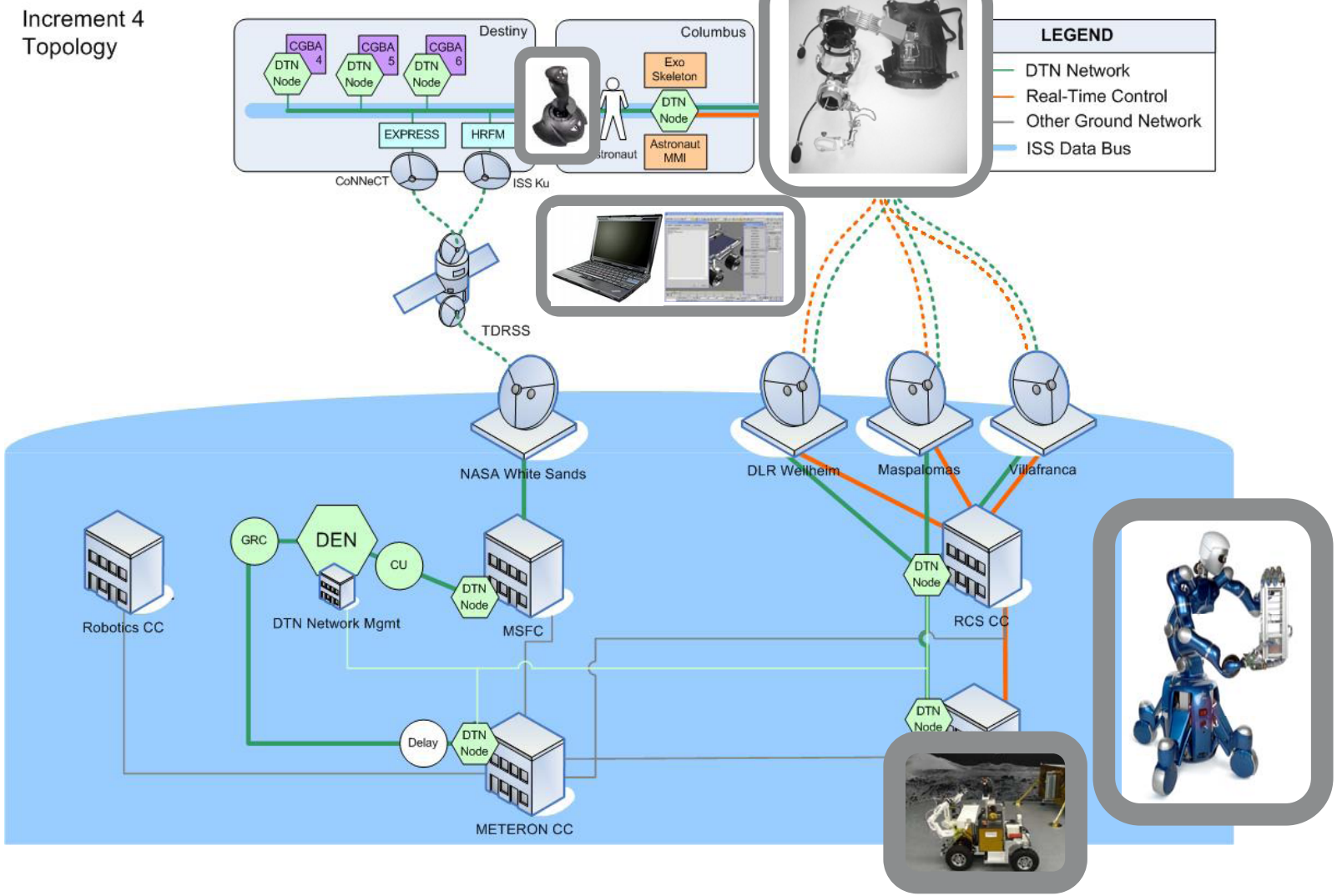
Phase 2 – Increment 4



Body-grounded F.-Feedback + Real-time 7 d.o.f. control

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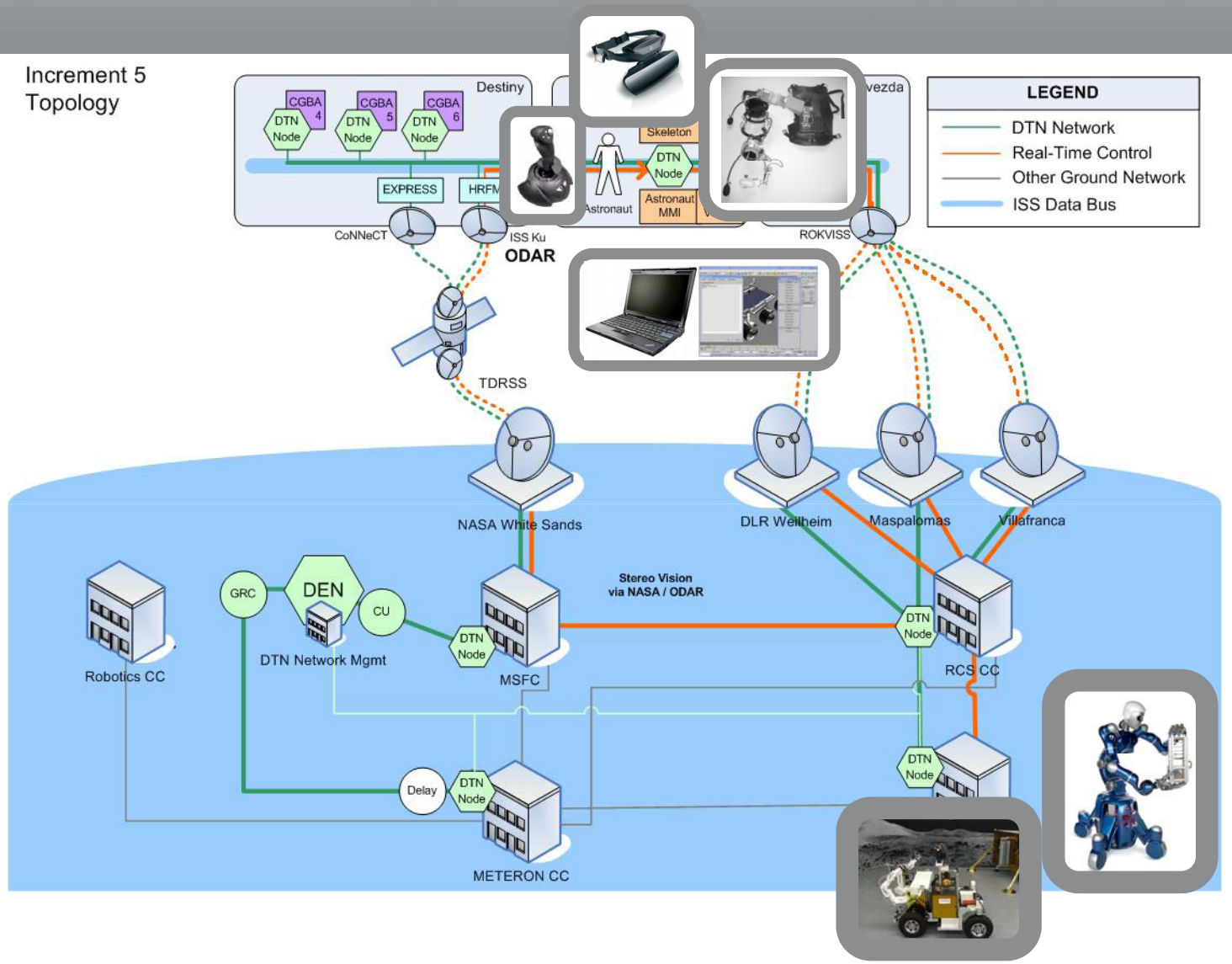
Phase 2 – Increment 5



Fully immersive teleoperation incl. 3D stereo feedback (ODAR availability)

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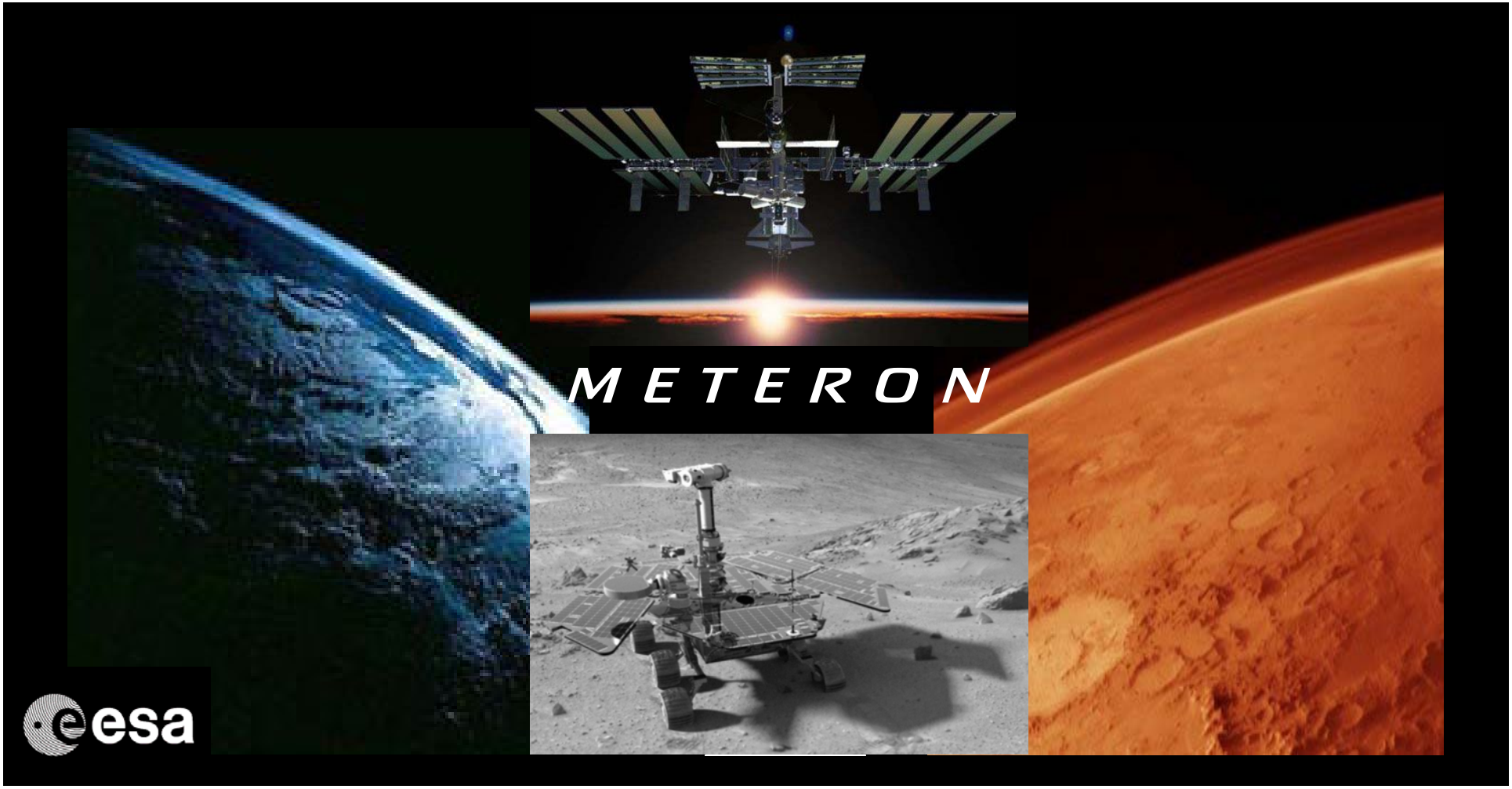

Thank you!